Application Serial No. 08/812,364 filed March 5, 1997 and issued as U.S. Patent No. 6,117,967, which is a continuation of prior U.S. Application Serial No. 07/696,408 filed May 5, 1991 and issued as U.S. Patent No. 5,846,896, which is a continuation of prior U.S. Application Serial No. 07/317,089 filed February 28, 1989, now abandoned, which is a continuation of prior U.S. Application Serial No. 07/034,472 filed April 3, 1987, now abandoned.

In the Claims

Claims 1-36 have been cancelled.

The following claims 37-78 have been added:

37. A polymer product comprising an isotactic polymer produced by the polymerization of an alpha olefin in the presence of a catalyst system comprising a transition metal component in the form of a chiral, stereorigid metallocene having the formula:

$$R''(C_5R'_m)_2\ Me\ Q_p$$

wherein $(C_5R'_m)$ is a substituted cyclopentadienyl group in which R is a hydrogen or a hydrocarbyl radical having from 1-20 carbon atoms, each R' being the same or different, and R" is a silicon hydrocarbyl radical acting as an interannular bridge between the two $(C_5\ R'_m)$ rings, provided that at least one R' is a hydrocarbyl radical imparting chirality to said stereorigid metallocene, Q is a hydrocarbon radical chosen from the group consisting of an aryl, alkyl, alkenyl, alkylaryl and arylalkyl radical having 1-20 carbon atoms or is a halogen; Me is a group 4b, 5b, or 6b metal as designated in the Periodic Table of Elements; $0 \leq m \leq 4$; and $0 \leq p \leq 3$.

38. The polymer product of claim 37 comprising an isotactic polymer produced by the polymerization of propylene in the presence of said catalyst system.

39. The polymer product of claim 38 produced by the polymerization of propylene in the presence of said metallocene in which at least one R' is a hydrocarbyl radical selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

40. The polymer product of claim 39 produced by the polymerization of propylene in the presence of said metallocene in which at least one R' of said metallocene is a phenyl or cyclohexyl group wherein C_5R' forms an indenyl radical or a hydrogenated indenyl radical.

41. The polymer product of claim 38 produced by the polymerization of propylene in the presence of said metallocene in which a first R′ is a phenyl group wherein ($C_5R'_m$) forms a substituted indenyl group.

42. The polymer product of claim 41 produced by the polymerization of propylene in the presence of said metallocene in which a second R′, a third R′, and a fourth R′ may be the same or different hydrocarbyl radicals having from 1-20 carbon atoms each and wherein one or more of such second R′, third R′, and fourth R′ may substitute on the indenyl group.

43. The polymer product of claim 42 produced by the polymerization of propylene in the presence of said metallocene in which the hydrocarbyl radicals are further defined as the same or different linear, branched, or cyclo hydrocarbyl radicals.

44. The polymer product of claim 43 produced by the polymerization of propylene in the presence of said metallocene in which the hydrocarbyl radicals are selected from a group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

45. The polymer product of claim 38 produced by the polymerization of propylene in the presence of said metallocene in which R'' is a dimethyl silyl group.

46. The polymer product of claim 38 produced by the polymerization of propylene in the presence of said metallocene in which ($C_5R'_m$) incorporates from 1 to 3 R' substituents which may be the same or different hydrocarbyl radicals each having from 1 to 20 carbon atoms substituted on the cyclopentadienyl group.

47. The polymer product of claim 46 produced by the polymerization of propylene in the presence of said metallocene in which the hydrocarbyl radicals are further defined as the same or different linear, branched, or cyclohydrocarbyl radicals.

48. The polymer product of claim 47 produced by the polymerization of propylene in the presence of said metallocene in which the hydrocarbyl radicals are selected from a group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

49. A polymer product comprising an isotactic polymer produced by the polymerization of propylene in the presence of a catalyst system comprising a transition metal component in the form of a chiral, stereorigid metallocene having the formula:

$$R''(C_5R'_m)_2\ Me\ Q_p$$

wherein $(C_5R'_m)$ is an indenyl group which may be unsubstituted or substituted with a hydrocarbyl radical R' having from 1-20 carbon atoms; R'' is a silicon hydrocarbyl radical which acts as an interannular bridge between the two $(C_5R'_m)$ groups; Me is a transition metal selected from the group consisting of a titanium, zirconium, and hafnium; Q is a hydrocarbon radical selected from the group consisting of aryl, alkyl, alkenyl, alkylaryl, and arylalkyl radical having 1-20 carbon atoms or is a halogen; m is from 0 to 4; and p is 2.

50. The polymer product of claim 49 produced by the polymerization of propylene in the presence of said metallocene in which $(C_5R'_m)$ is a substituted indenyl group and each R' is selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, and phenyl.

51. The polymer product of claim 50 produced by the polymerization of propylene in the presence of said metallocene in which R'' is a dimethyl silyl or a cyclopropyl silyl group bridging said $(C_5R'_m)$ groups.

52. The polymer product of claim 51 produced by the polymerization of propylene in the presence of said metallocene in which Me is titanium.

53. The polymer product of claim 52 produced by the polymerization of propylene in the presence of said metallocene in which Me is zirconium.

54. The polymer product of claim 53 produced by the polymerization of propylene in the presence of said metallocene in which Me is hafnium.

55. The polymer product of claim 49 produced by the polymerization of propylene in the presence of said metallocene which is a dimethyl silyl bis(indenyl) zirconium dichloride in which the indenyl is substituted with a substituent selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, and phenyl.

56. A polymer product comprising an isotactic polymer produced by the polymerization of propylene in the presence of a catalyst system comprising a transition metal component in the form of a chiral, stereorigid metallocene having the formula:

$$R''(C_5R'_m)_2\ Me\ Q_p$$

wherein $(C_5R'_m)$ is an indenyl group which is substituted with at least one hydrocarbyl radical R' having from 1-20 carbon atoms; R'' is an alkylene radical having 1 to 4 carbon atoms which acts as an interannular bridge between the $(C_5R'_m)$ groups or is a silicon hydrocarbyl which acts as an interannular bridge between the two $(C_5R'_m)$ groups; Me is a transition metal selected from the group consisting of a titanium, zirconium, and hafnium; Q is a hydrocarbon radical selected from the group consisting of aryl, alkyl, alkenyl, alkylaryl, and arylalkyl radical having 1-20 carbon atoms or is a halogen; m is from 1 to 4; and p is 2.

57. The polymer product of claim 56 produced by the polymerization of propylene in the presence of said metallocene in which R'' comprises a methylene or ethylene bridge between the $(C_5R'_m)$ groups.

58. The polymer product of claim 57 produced by the polymerization of propylene in the presence of said metallocene in which at least one R' hydrocarbyl radical is selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

59. The polymer product of claim 58 produced by the polymerization of propylene in the presence of said metallocene in which Me is titanium and Q is chlorine.

60. The polymer product of claim 58 produced by the polymerization of propylene in the presence of said metallocene in which Me is hafnium and Q is chlorine.

61. The polymer product of claim 58 produced by the polymerization of propylene in the presence of said metallocene in which Me is zirconium and Q is chlorine.

62. The polymer product of claim 56 produced by the polymerization of propylene in the presence of said metallocene in which R" is a dimethyl silyl group.

63. The polymer product of claim 62 produced by the polymerization of propylene in the presence of said metallocene in which at least one R' is selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

64. The polymer product of claim 63 produced by the polymerization of propylene in the presence of said metallocene in which Me is titanium and Q is chlorine.

65. The polymer product of claim 63 produced by the polymerization of propylene in the presence of said metallocene in which Me is hafnium and Q is chlorine.

66. The polymer product of claim 63 produced by the polymerization of propylene in the presence of said metallocene in which Me is zirconium and Q is chlorine.

67. A catalyst system useful for the polymerization of an alpha olefin comprising a chiral, stereorigid metallocene catalyst component having the formula:

$$R''(C_5R'_m)_2MeQ_p$$

wherein $(C_5R'_m)$ is a substituted cyclopentadienyl group in which R is a hydrogen or a hydrocarbyl radical having from 1-20 carbon atoms, each R' being the same or different, and R" is a silicon hydrocarbyl radical acting as an interannular bridge between the two $(C_5 R'_m)$ rings, provided that at least one R' is a hydrocarbyl radical imparting chirality to said stereorigid metallocene, Q is a hydrocarbon radical chosen from the group consisting of an aryl, alkyl, alkenyl, alkylaryl and arylalkyl radical having 1-20 carbon atoms or is a halogen; Me is a group 4b, 5b, or 6b metal as designated in the Periodic Table of Elements; $0 \leq m \leq 4$; and $0 \leq p \leq 3$;

and a cocatalyst component effective to activate said metallocene catalyst component.

68. The catalyst system of claim 67 wherein a first R′ is a phenyl group wherein ($C_5R'_m$) forms a substituted indenyl group.

69. The catalyst system of claim 68 wherein a second R′, a third R′, and a fourth R′ may be the same or different hydrocarbyl radicals having from 1-20 carbon atoms each and wherein one or more of such second R′, third R′, and fourth R′ may substitute on the indenyl group.

70. The catalyst system of claim 69 wherein the hydrocarbyl radicals are further defined as the same or different linear, branched, or cyclo hydrocarbyl radicals.

71. The catalyst system of claim 70 wherein the hydrocarbyl radicals are selected from a group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

72. A catalyst system useful for the polymerization of an alpha olefin comprising a chiral, stereorigid metallocene catalyst component having the formula:

$$R''(C_5R'_m)_2\ Me\ Q_p$$

wherein ($C_5R'_m$) is an indenyl group which is substituted with at least one hydrocarbyl radical R′ having from 1-20 carbon atoms; R″ is an alkylene radical having 1 to 4 carbon atoms which acts as an interannular bridge between the ($C_5R'_m$) groups or is a silicon hydrocarbyl which acts as an interannular bridge between the two ($C_5R'_m$) groups; Me is a transition metal selected from the group consisting of a titanium, zirconium, and hafnium; Q is a hydrocarbon radical selected from the group consisting of aryl, alkyl,

alkenyl, alkylaryl, and arylalkyl radical having 1-20 carbon atoms or is a halogen; m is from 1 to 4; and p is 2,

and a cocatalyst component effective to activate said metallocene catalyst component.

73. The catalyst system of claim 72 wherein R'' comprises a methylene or ethylene bridge between the ($C_5R'm$) groups.

74. The catalyst system of claim 73 wherein said at least one R' hydrocarbyl radical is selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

75. The catalyst system of claim 74 wherein Q is chlorine.

76. The catalyst system of claim 72 wherein R" is a dimethyl silyl group.

77. The catalyst system of claim 76 wherein said at least one R' is selected from the group consisting of methyl, ethyl, propyl, butyl, amyl, isoamyl, hexyl, isobutyl, heptyl, octyl, nonyl, decyl, cetyl, cyclohexyl, and phenyl.

78. The catalyst system of claim 77 wherein Q is chlorine.

Remarks

The claims in this application are directed to catalyst systems useful in the polymerization of alpha olefins and polymer products comprising an isotactic polymer produced by the polymerization of an alpha olefin, specifically propylene, in the presence of such catalyst system. The claims directed to a catalyst system call for a chiral, stereorigid metallocene catalyst component and a cocatalyst component effective to activate the metallocene component. The